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Rev. 0

Use of HEPA Filtered Vacuum Cleaners and Portable Ventilation Systems

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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P.O. Box 1000
Richland, Washington

Contractor for the U.S. Department of Energy
Richland Operations Office under Contract DE-AC06-96RL13200

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to describe use of High Efficiency Particulate Air (HEPA) filtered vacuum cleaners and portable ventilation systems for radiological work. This document describes how these engineered controls are installed and used to ensure safe operation and positive control of these resources.

1.2 Scope

This document summarizes the PHMC requirements and provides detailed guidelines for using HEPA filtered vacuum cleaners and portable ventilation systems used for radiological work.

1.3 Background

The control of radioactive contamination during operations where the potential for airborne radioactivity exists can be substantially improved and maintained ALARA by using HEPA filtered vacuum cleaners or portable ventilation systems. Effective use of these engineered controls captures particulate contamination at the source, thereby minimizing its spread. In addition to improved worker comfort and efficiency, immediate reductions in the use of respiratory protection equipment, decontamination time, and waste generation can be realized.

Use of engineering and administrative controls to reduce the potential for internal exposure should be evaluated before allowing personnel, with or without respiratory protection, to enter areas with airborne radioactivity.

1.4 Definitions

1.4.1 Fissionable Material - Radionuclides that are capable of sustaining a neutron chain reaction, including ^{233}U, ^{235}U, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{247}Cm, ^{249}Cf, and ^{251}Cf. Natural Uranium, depleted uranium, and thorium are not considered to be fissionable materials.

1.4.2 High Efficiency Particulate Air (HEPA) Filter - A filter with media that provides highly efficient filtration of particulates in the air with a minimum of 99.97 percent efficiency for capturing particles that are 0.3 micron median diameter. Once installed for use, HEPA filters are tested to assure a minimum of 99.95 percent efficiency for capturing polydispersed test aerosol with a median diameter of 0.7 micron.

1.4.3 Prefilter - A filter that provides the first stage of air filtration to remove larger particulates and material drawn into the vacuum cleaner or ventilation system.

1.5 Responsibilities

Improper use of vacuum cleaners or portable ventilation systems may cause the spread of contamination and increase radiation dose rates. Use of the ISM process for hazard identification and work planning integrate the specific needs of the individual worker, radiological control technician, and their managers.

1.5.1 General Management Responsibility

Provide HEPA filtered vacuum cleaners and portable ventilation equipment; establish standards, training, and appropriate work instructions for operating personnel.

1.5.2 General User Responsibility

Each individual who installs or uses a HEPA filtered vacuum cleaner or portable ventilation system is responsible for verifying it is in proper operating condition.

1.5.3 Radiological Control Personnel

Radiological control personnel perform monitoring of vacuum cleaners and portable ventilation systems in accordance with this procedure and provide RCT coverage, as required, for opening these systems.

1.5.4 Criticality Safety Engineer

Reviews planning and procedures that involve the use of HEPA filtered vacuums and portable ventilation systems when fissionable material will be collected.

1.5.5 Industrial Hygiene and Safety Engineer

Ensures that workers wear the proper PPE and equipment when cleaning or performing maintenance on equipment containing hazardous materials.

1.5.6 Vent and Balance

Conduct HEPA filter efficiency tests and flow checks when requested by line management.

1.5.7 Line Management

- Responsible for proper functioning of HEPA filtered vacuum cleaners and portable ventilation systems.
- Ensures trained personnel operate these systems in radiological areas.
- Ensures HEPA filter efficiency tests are performed as required.
- Line management provides instruction to radiological workers on the installation, use, removal, and maintenance of HEPA filtered vacuum cleaners and portable ventilation units.
- Line management also controls the use of the vacuums and portable ventilation systems to ensure unauthorized personnel do not use them.

- Ensure HEPA filtered vacuum cleaners and portable ventilation systems are utilized in compliance with the applicable environmental clean air requirements.

2.0 USE OF HEPA FILTERED VACUUM CLEANERS

Installation and operation of HEPA filtered vacuum units reduce the spread of contamination during radioactive work. Specific requirements for an activity or installation should be identified in the work or operation document.

Vacuum cleaners can be used to provide negative ventilation in glove bags as well as clean radioactive chips and debris from surfaces inside containments and other contaminated areas. Article 464 of the PHMC Radiological Control Manual provides specific requirements related to using vacuum cleaners.

Note: Vacuum cleaners are different from portable ventilation systems in that they include a container, which collects airborne debris.

2.1 Vacuum Cleaner Description

Vacuum cleaners are designed to collect radioactive debris and concentrate it in a small area. HEPA filtered vacuum cleaners come in several shapes and sizes and may be either electrically or pneumatically operated.

The quality of construction varies with the cost and the rated airflow. In some cases, inexpensive HEPA filtered vacuum cleaners are purchased with the intent to use them until they are either full or the aerosol leak test expires. These vacuum cleaners are then disposed as radioactive waste instead of being emptied and/or retested. This can save dose and eliminate the risk of contamination spread.

In other cases, more expensive vacuum cleaners are purchased which have higher flow rates and can be emptied without affecting the HEPA filter seal. These vacuum cleaners can be emptied multiple times without repeating the aerosol test of the HEPA filter.

A typical vacuum cleaner contains a HEPA filter, a bag or container for collecting debris, and a vacuum cleaner hose. Debris sucked into the hose is deposited in the container. The air passes through the container and may be drawn through an additional prefilter prior to the HEPA filter before passing through the fan motor. In some situations, lining the container with a bag aids in material control and significantly reduces maintenance time (ALARA). The disposable bag, prefilter, and HEPA filter progressively filter minute particulate from the air stream. For example, the openings in the disposable bag filter material that is 40-60 microns in diameter. The additional filters will typically filter 8 microns to 2 microns before passing through the HEPA filter, which filters 0.3 micron and smaller.

Some vacuum cleaners are capable of wet and dry collection. If the debris being collected is wet, a wet/dry vacuum should be used or the moisture will damage the HEPA filter on a vacuum cleaner that is not designed for liquids.

2.2 Requirements For Using Vacuum Cleaners

FH has established mandatory requirements that must be followed to use HEPA filtered vacuum cleaners for radiological work. These requirements are identified in other mandatory documents. This section provides a summary of requirements. The Radiation Protection Program requirements are located in the PHMC Radiological Control Manual, HNF-5173, Article 464. Environmental clean air requirements are located in the HNF-RD-8703, Section 4.3.3. Additional information to support overall implementation of these requirements is provided below.

2.2.1 Radiation Protection and Occupational Safety Requirements

Improper use of vacuum cleaners and portable air-handling equipment may result in the generation of airborne radioactivity, loose surface contamination, or high dose rates.

a. Vacuum cleaners and portable air-handling equipment used in areas established to control removable surface contamination or airborne radioactivity (except areas where only tritium is present) should be equipped with High-Efficiency Particulate Air (HEPA) filters. If the material to be vacuumed is wet enough to preclude resuspension, then HEPA filters are not necessary.

b. HEPA filters used in vacuum cleaner and portable air-handling equipment should meet the efficiency and construction requirements for HEPA filters.

- The maximum flow rate of the device should not exceed the flow rate at which the HEPA filter was efficiency tested. At a minimum, devices should be tested prior to use and annually.

- In addition, devices with integral filter assemblies should be efficiency tested when units have been opened. HEPA devices which are designed to be serviced to allow debris removal without compromising the HEPA filter seal (e.g., the Nilfisk GS-80 and the Euroclean “HEPA filtered Portable Dust Collection System”) do not have to be leak tested every time they are opened. If, however, the HEPA filter seal is affected during debris removal or servicing, then an efficiency test should be performed.

  - At Hanford, aerosol testing is performed using Facility Maintenance Procedure 7-GN-062.

  - Additional requirements for efficiency testing are contained in the applicable radioactive air emissions notice of construction and ERDA 76-21, Section 8.3.1.

- The aerosol-testing sticker should be installed so that it will have to be torn to separate the unit at the HEPA filter seal.

- In addition, inspect the unit to ensure Vent and Balance has installed the HEPA Filter Service Record Tag.

- If the vacuum cleaner is used for asbestos or lead work, label the vacuum cleaner to clearly identify these hazards.

- The frequency of aerosol testing should be increased if the vacuum cleaner becomes highly radioactive and/or the vacuum is exposed to hostile environments such as high moisture loading, chemical fumes, or is exposed to high temperatures.

- The specifications used at Hanford for the procurement of HEPA filters are:

  Note: ASME AG-1, Section FC, superseded Mil-51068.

  - WHC-S-0462, "Specification for Procurement of Portable Nuclear Grade HEPA Filtered Vacuum Cleaners and Replacement Filters"

  - WHC-S-0463, "Specification for Procurement of Portable Exhaust Equipment and Replacement Filters"

- Ventilation and balance recommends that vacuum cleaners used for asbestos or lead radiological work be retested at six-month intervals.

- If the vacuum cleaner is used for only radiological work, it must be retested every twelve months (or if the seal is damaged/broken).

  Note: If the date on the aerosol testing sticker will expire before the job is completed, then have the vacuum cleaner retested or obtain another vacuum cleaner.

- Criticality Review required by HNF-5173, Article 464.6 - This requirement applies to facilities that have a credible chance for a criticality incident as defined by the facility Safety Basis document.

c. Vacuum cleaners and portable air-handling equipment identified in HNF-5173, Article 464.1 should be:

- Uniquely marked and labeled,
- controlled by an RWP,
- controlled to prevent unauthorized use,
- designed to ensure HEPA filter integrity under conditions of use, and
- designed to prevent unauthorized or accidental access to the inner surfaces of the vacuum.

d. Radiation and contamination surveys should be performed periodically for vacuum cleaners in use and labels on these units should be updated.

- The frequency of radiation surveys should depend on the specific use of the vacuum cleaner.
- Airborne radioactivity levels should be monitored when a vacuum cleaner is used in a high contamination area.

e. Depending on the environment and work activity, various radiologically posting and labeling requirements may exist. Some common examples are:

- HNF-5173, Article 231 and 236 - The vacuum cleaner should have a "CAUTION RADIOACTIVE MATERIAL - INTERNALLY CONTAMINATED" label placed on the external surface of each section of the vacuum cleaner as soon as it is used for radiological work.

- If the vacuum cleaner is used in an RBA, place a "CAUTION RADIOACTIVE MATERIAL - POTENTIAL FOR INTERNAL CONTAMINATION" label on the external surface of each section of the vacuum cleaner.

- HNF-5173, Article 231 and 236 - The vacuum cleaner should have a "CAUTION RADIOACTIVE MATERIAL - INTERNALLY CONTAMINATED" label placed on the external surface of each section of the vacuum cleaner as soon as it is used for radiological work.

- If the vacuum cleaner is used in an RBA, place a "CAUTION RADIOACTIVE MATERIAL - POTENTIAL FOR INTERNAL CONTAMINATION" label on the external surface of each section of the vacuum cleaner.

- This aerosol testing sticker should be installed so that it will have to be torn to separate the unit at the HEPA filter seal. In addition, inspect the unit to ensure Vent and Balance has installed the HEPA Filter Service Record Tag.

- If the vacuum cleaner is used for asbestos or lead work, label the vacuum cleaner to clearly identify these hazards.

- The vacuum cleaner should have a current aerosol test sticker attached and should have been tested within the last six months (if used for asbestos or lead) or twelve months (if used for radiological work).

f. If the vacuum cleaner is past due for retesting, remove it from service.

g. HNF-5173, Article 551, requires that radiological monitoring be performed before, during, and at the completion of work that has the potential for causing changes in levels of radiation or radioactivity. Since the vacuum cleaner concentrates the radioactivity in a small area, radiation levels can increase significantly in a short time period.

h. In addition to the requirements of HNF-5173, Articles 551 and 552.1, additional surveillance requirements may apply to the work area or posted area. Examples are:

- Weekly, for operating HEPA-filtered ventilation units

  Note: This should also apply to a vacuum cleaner if it is being used as a source of ventilation.

- Monthly for potentially contaminated ducts, piping, and hoses in use outside radiological control facilities {HNF-5173, Article 552.1}

2.2.2 Environmental Requirements

a. HNF-PRO-8703, Section 4.3.3 requires compliance with the HEPA Vacuum Sitewide Notice of Construction, DOE/RL-97-50, *Radioactive Air Emissions, Notice of Construction, High-Efficiency Particulate Air (HEPA) Filtered Vacuum Radioactive Air Emission Units.*

2.3 Radiation Protection Guidelines For Using HEPA Filtered Vacuum Cleaners

This section contains additional guidance that may apply to the specific vacuum cleaner application. The work controls for the activity should include the following:

2.3.1 Installation

a. Prior to using a vacuum cleaner in a fissile facility that has a potential for a criticality incident, verify that a Nuclear Safety Review has been performed and the use of the vacuum cleaner is authorized by the technical work document or RWP.

b. If the vacuum cleaner is going to be used to collect hazardous materials (mixed waste), notify the Industrial Hygiene Engineer to determine if any additional personnel protective clothing (PPE) or equipment is required.

c. Vacuum cleaners should be used only for specific tasks included in the work package and approved by Project/Activity Radiological Control and for which an RWP has been issued. The RWP should specify any precautions or limitations on the use of the vacuum cleaner. Some examples of tasks for which vacuum cleaners are used include:

- General cleaning in contaminated areas,
- post-job cleanup and decontamination in contaminated areas,
- cleanup and decontamination following a spill of radioactive material,
- removal of debris from contaminated plant systems following maintenance operations such as grinding, lapping, or filing, and
- providing negative ventilation for a small glove bag or glove box containments

d. Vacuum cleaners used in contaminated areas should be protected from external contamination as much as practical using techniques such as the following:

- Wrap the unit in plastic except for the exhaust port and any motor air-cooling ports.
- If the unit has wheels, apply tape over the tread area and sidewalls.
- Sleeve hoses and ducting.
- Paint the unit with strippable latex decontamination paint prior to taking the unit into the contaminated area.

e. Vacuum cleaners are obtained from the line organization responsible for their custody. At a minimum, vacuum cleaners are controlled and stored as radioactive material after they have become internally contaminated. Verify the aerosol test sticker and any security seals are intact when obtaining a vacuum cleaner.

f. The vacuum cleaner should be returned to the responsible organization at the end of the shift unless the work extends over a longer period of time and permission has been obtained to leave the vacuum cleaner at the work area.

g. Protective clothing requirements for handling a contaminated vacuum cleaner hose will be listed on the RWP. Normally, a vacuum cleaner hose has the nozzle bagged in plastic material when not in use. Extra care should be used when handling vacuum cleaner hoses as they become highly contaminated internally. If the vacuum cleaner hose is installed in a glove bag for negative ventilation, it is not necessary to bag the hose end after each use if the glovebag remains closed (or certified if appropriate).

h. The hose and vacuum cleaner are considered radioactively contaminated and should be controlled as radioactive material. Verify the vacuum cleaner is appropriately marked with radiological and/or asbestos/lead labels.

i. For best results, position the vacuum cleaner as close to the containment or work area as practicable in order to reduce the length of hose and the number of bends. If the hose must be bent, minimize sharp or excessively wide bends to reduce the pressure drop through the system. Do not route the hose through high traffic areas. Install enough hose in the work area to reach all areas where there is a need to vacuum debris or where airborne producing work will be performed. The suction hose should be able to draw airborne particulate away from the worker's breathing zone.

   Ensure the air exhaust ports on the vacuum cleaner will not cause a turbulence, which could result in a spread of contamination. Identify the exhaust flow prior to use as some models of vacuum cleaners exhaust out the bottom of the unit.

j. If the vacuum cleaner is being used to provide negative ventilation, the ideal hose should be larger in diameter than the source diameter and have enough flow to capture airborne particulate. Since vacuum cleaner hoses are usually less than 2" in diameter, there is usually a high flow velocity, and the key to capturing airborne particulate is positioning the hose within one duct diameter of the source. See Section 3.2 for additional information.

k. Securely clamp and/or tape all hose connections to ensure they do not separate during work. It is common practice for workers to move the vacuum cleaner by pulling on the hose. This should be discouraged as it may cause leaks at the hose connections, and the vacuum cleaner may tip over and be damaged.

l. Periodically visually check the unit including the hoses and/or ducting to determine if there are any openings or breaks in the system. Consider attaching a screen on the end of the suction hose to prevent large items from being sucked into the system.

m. When possible, secure the vacuum cleaner in an upright position using rope or wire to prevent tipping.

n. Verify the aerosol test label is intact and the aerosol test was completed within the last six months (recommended for asbestos or lead) or twelve months (for radiological).

o. If a wet/dry vacuum cleaner is being used, verify the bottom drain is secured.

p. Each vacuum cleaner should have a security seal or other form of locking device attached to prevent unauthorized or accidental opening during use. Verify the security seal or locking device is intact before use. If the seal is not intact or the locking device is broken or inadequate, remove the equipment from service and have the unit repaired and the efficiency test repeated.

   Note: The locking devices on some of the inexpensive vacuum cleaners are inadequate for radiological work and should be checked closely. Locking devices that are easily broken during movement and use, or constructed in materials that might fail during use, should be avoided.

   Often facilities will augment manufacture installed locking devices. Facilities have installed banding or hose clamps to aid in ensuring the vacuum cleaner assembly remains intact.

q. If the vacuum cleaner is installed in a glove bag and is used to provide negative ventilation as well as for debris collection, provisions will have to be made to allow "make-up" air to enter the glove bag to replace the air removed by the vacuum cleaner. This is normally accomplished by having the glove bag constructed with a section of filter media that allows air to enter the glove bag or by installing a 30-40 CFM HEPA filter in the glove bag.

r. Some manufacturers sell small vacuum cleaners or ventilators that have a variable speed controller so the user can regulate the flow. These are highly recommended for glove bag use. Information on these products can be obtained through the ALARA Center of Technology at 376-0818 or 372-8961.

s. If the vacuum cleaner is to be used to collect a large amount of metal chips and debris, consider installing a chip collector in the suction line between the end of the hose and the vacuum. Figures 1A, *Chip Collector Made From Waste Drums,* and 1B, *Chip Collector Made from Waste Drum With Filter,* provide suggested designs for chip collectors that can be manufactured from various size waste drums. Special drum lids that convert a waste drum into a chip collector are also commercially available.

t. For best results, the vacuum cleaner and collection drum should be positioned near each other and the two hoses kept as short as practical. This will provide maximum suction and ensure the debris can be sucked into the hose and deposited in the drum.

   Hint: The commercial lids have a thick gasket, which makes it difficult to install the bolting ring. Turn on the vacuum cleaner after the lid is in position and the lid will collapse the gasket making it easy to install the bolting ring.

Figure 1A

Chip Collector Made From Waste Drums

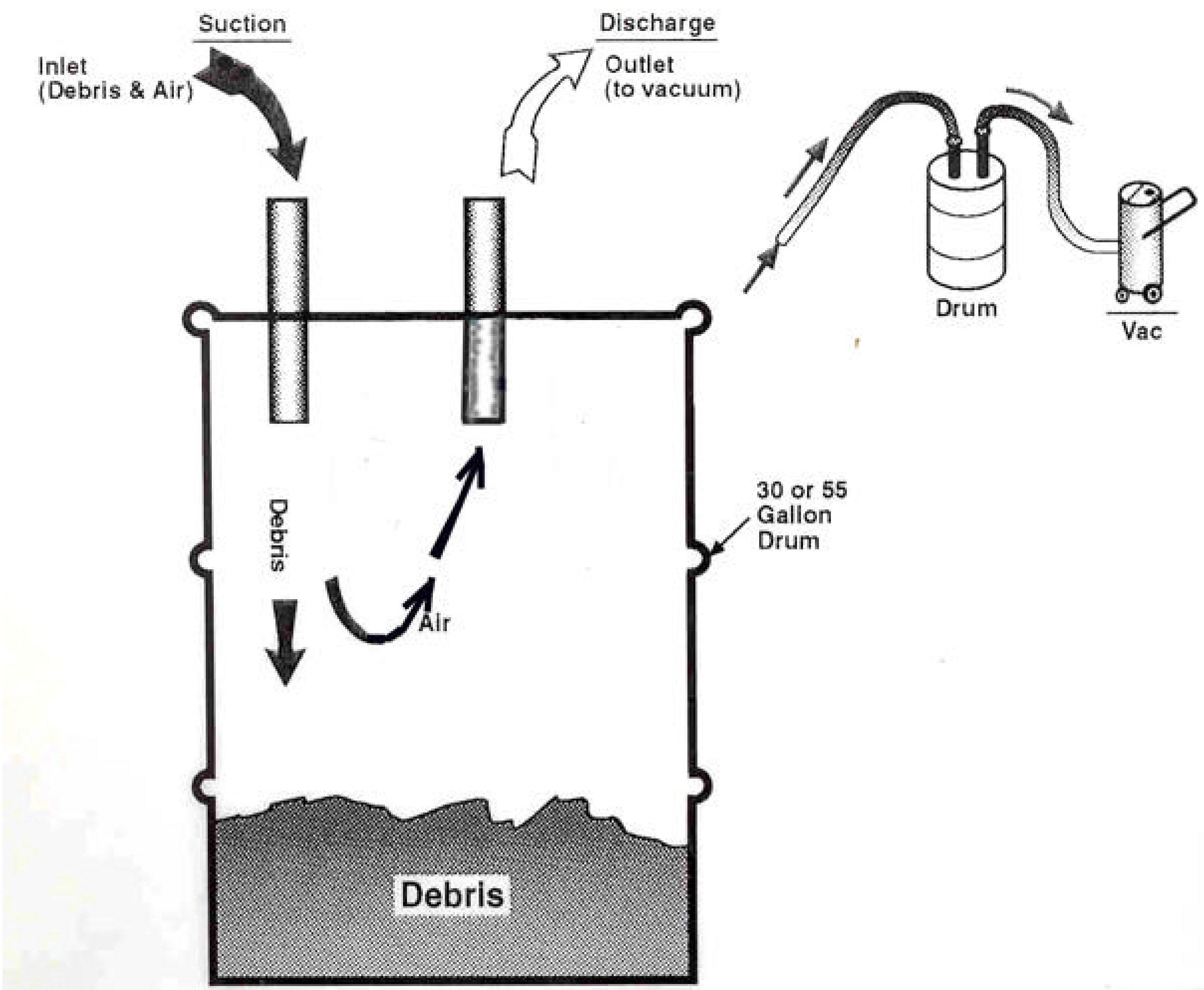


Figure 1A: Modify a drum lid by welding two pipe sections through openings cut into the lid. The size of pipe will be determined by the inside diameter of the vacuum hose. Debris is deposited directly into the waste drum that eliminates later clean out of the vacuum cleaner canister.

Figure 1B

Chip Collector Made From Waste Drum With Filter

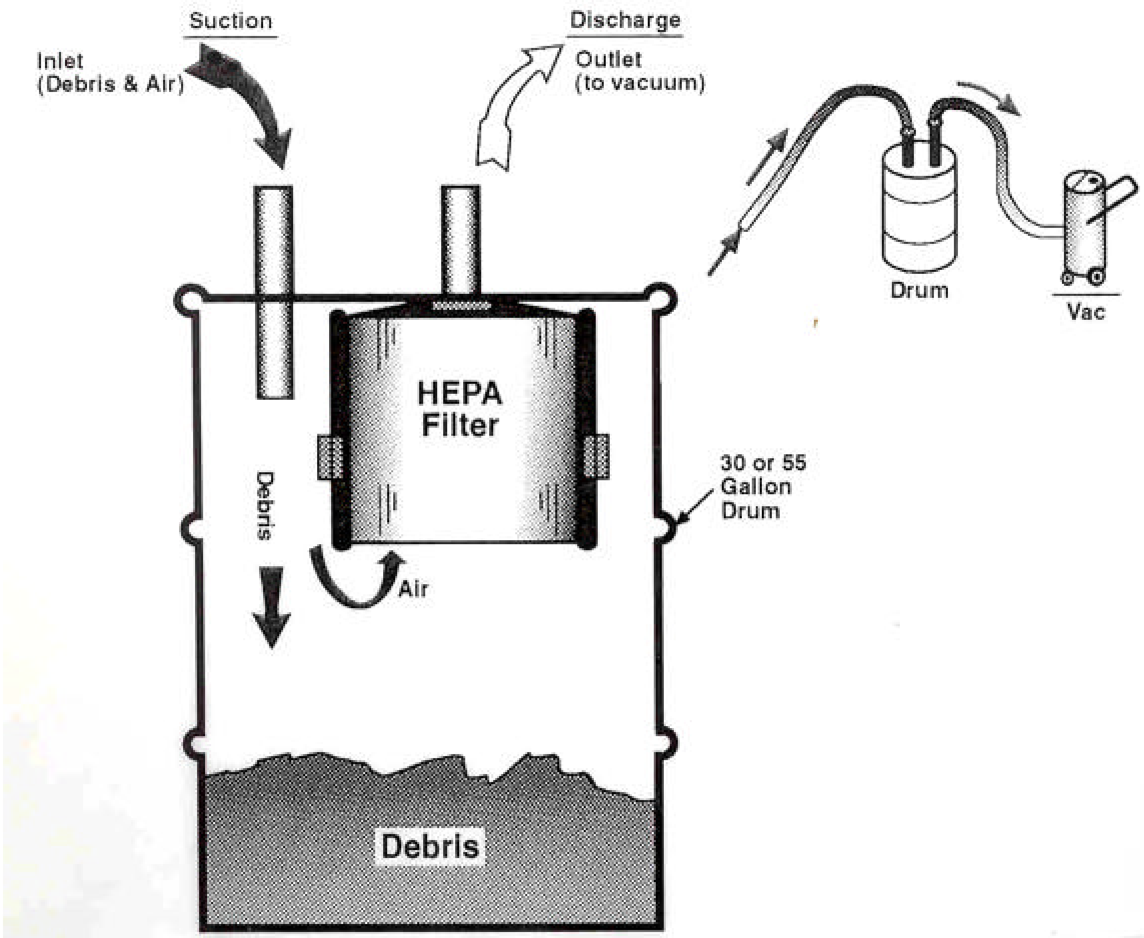


Figure 1B is similar to Figure 1A, except a HEPA filter is mounted on the inside of the drum lid on the discharge side. This drum will collect the debris and filter the air going to the vacuum cleaner. This system is useful when collecting highly radioactive debris or mixed waste.

u. If the vacuum cleaner is going to be used on highly radioactive systems that will cause the HEPA filter to become highly radioactive, consider installing an in-line HEPA filter between the end of the hose and the vacuum cleaner. Figure 2, *In-Line HEPA Filter*, shows an in-line filter assembly that can be made by adapting an existing HEPA filter to fit the suction hose. Highly radioactive particles deposited on the in-line filter will not affect the system's main HEPA filter.

- The in-line filter can be replaced when it becomes highly radioactive or temporarily shielded until the job is complete. Replacement of the in-line HEPA filter does not effect the efficiency test on the vacuum cleaner HEPA filter since it is being used like an additional prefilter.

- If possible, locate the in-line HEPA filter inside the containment tent, if installed, to make it easier to change the filter if it becomes too highly radioactive during use.

- If the vacuum cleaner or in-line HEPA filter was used to collect mixed or TRU waste, the filter and contents must be handled as mixed/TRU waste.

v. If the vacuum cleaner must operate continuously while the job is in progress, consider "Caution tagging" the electrical connections and switches or airline valves if the vacuum cleaner is pneumatically operated. This will ensure the unit is not inadvertently secured during use.

w. If the job requires that liquids be removed by vacuuming, ensure the vacuum cleaner has the capability for wet/dry operation and the RWP or work procedure authorizes the use of the vacuum cleaner for this purpose.

- The work package should establish controls to ensure the container is not overfilled.

- The vacuum cleaner should be removed from service and drained, as soon as practicable, after it is used to collect liquid.

- If liquid is accidentally sucked into a vacuum cleaner that is not designed for liquids, the vacuum cleaner should be removed from service, drained, and another aerosol test performed before further use.

Note: The commercially available drum lids described above have a float device that allows a waste drum to be used to collect liquids. As the waste drum fills with liquid, a floating ball plugs the connection on the lid stopping the suction. This allows you to install a "dry" vacuum cleaner connected to a waste drum and use the vacuum cleaner to collect liquids into the waste drum.

x. Mark one or more reference points on the vacuum cleaner so the Radiological Control Technician can then take contact radiation readings as part of the required monitoring. By monitoring the same location each time, it is possible to see increasing trends in radiation levels. These reference points are normally on the outside of the vacuum cleaner near the HEPA filter, on the bottom of the debris collection section, or on the hose at low points or connections.

y. Section 2.4 and 3.4 below describe the requirements necessary to operate within the established environmental clean air requirements for discharging emissions from a HEPA filtered ventilation system directly to the environment. These permits are not required for small hand-held pistol-grip type vacuum cleaners that are used to collect debris. If the vacuum cleaner is being used to provide negative ventilation to a glove bag and will exhaust directly to the environment, contact the Project/Activity Environmental representative.

z. If a single vacuum cleaner will not provide enough suction, another vacuum cleaner can be installed and their suction hoses "wyed" together as shown in Figure 3, *Typical Vacuum Cleaner* Installations. In addition, a single vacuum cleaner can be used to service multiple locations. These "wye" connections can be made by site sheet metal shops or obtained from vendors.

Figure 2

In-Line HEPA Filter

1. Obtain a HEPA filter that has a rated airflow equal to or more than the flow of the system. The filter may be either round or square and will probably be found in a facility's spare parts inventory for a portable ventilation system or the filter for a radioactive collection tank. If the facility does not have a suitable HEPA filter, contact Radiological Engineering for assistance.

2. Manufacture adapters to fit the ventilation/vacuum cleaner hose.

3. Tape and/or clamp adapters to each end of the HEPA filter.

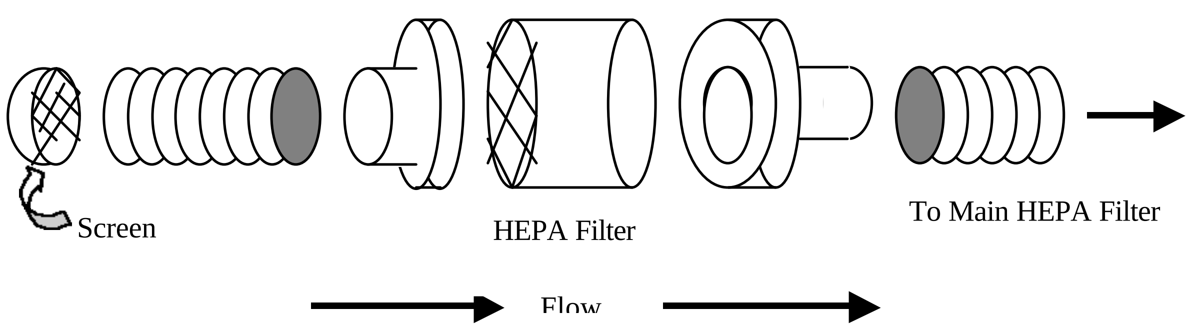
4. Locate the position in the hose where the in-line filter will be installed and tape or clamp the hoses to the adapters. The filter should be installed inside the containment tent or in a separate glovebag if it is expected it will have to be changed during use. This will simplify the radiological controls for changing the filter. If present, verify the flow arrows are pointed in the same direction as the air will flow through this system.

5. Install a screen over the end of the suction hose to prevent large objects from being sucked into the hose and reducing the flow rate.

6. If radiation levels are expected to increase on the filter during use, temporary shielding should be installed on the filter prior to starting work. RCTs should take periodic surveys of the filter during use to ensure it does not become a major source of radiation to personnel performing the work.

7. The in-line filter should be changed whenever the flow is significantly reduced or when directed by the RCT due to high radiation levels.

   Advantages: In-line filters will protect an expensive HEPA filtered ventilation/vacuum system so it will not become highly radioactive. Changing the in-line filter will not affect the aerosol test of the main system since this filter is being used as a pre-filter. At the completion of the job, the in-line filter can be disposed of easily as radioactive waste. This reduces the expending of additional radiation exposure that would be encountered if the entire system were highly radioactive.



2.3.2 Radiological Vacuum Cleaner Operation

a. Personnel should be familiar with vacuum cleaner use. The operation of the vacuum cleaner should be included in applicable prejob briefings to ensure involved personnel understand any special requirements associated with the job.

b. Workers using a HEPA filtered vacuum cleaner to remove debris should wear the required PPE listed on the RWP. The vacuum cleaner should be turned on before removing the plastic bag covering the hose end. The period of time the vacuum cleaner runs with the hose bagged should be minimized.

c. If the vacuum cleaner is being used to provide "localized" ventilation in the work area, the workers should position the end of the hose near the source of contamination at 90 to 180 degrees away from the worker. Figure 4, *Velocity Contours – Plain Circular Hose Inlet Opening - Percent of Opening Velocity*, shows an air velocity diagram at the end of an open hose. A review of Figure 4 shows a significant drop in velocity as the hose is moved away from the source. As a rule of thumb, users should keep within one duct diameter of the source.

   Figures 5A, *Containment Tent Ventilation*, and 5B, *Position of Localized Ventilation*, show how a vacuum cleaner or ventilation hose should be positioned to be most effective.

   Position the hose close to the contaminated surface in a location that will draw airborne particulate away from the worker. The distance to position the hose end from the source is recommended to be less than the diameter of the suction hose.

d. Airflow control will keep the contamination from spreading throughout the containment and reduce the area that becomes contaminated during work. When combined with other measures, e.g., covering contamination with fixatives or strippable paint, Radiological Control personnel may be able to reduce or eliminate the need for respiratory protection. If inert gas welding is required, the welders should determine how close the suction hose could be so the inert gas is not sucked away from the weld area.

e. If a loss of suction occurs during operation, secure work activities, check for an obstructed hose, damaged gasket, a full collection bag, or holes in the hose or components. Depending on the kind and amount of radioactive material present, the responsible organization will have to decide whether to trouble-shoot and fix the existing system or replace the vacuum cleaner. The plugged vacuum cleaner can either be disposed as radioactive waste or disassembled for unclogging or emptying the unit.

f. If the hose is clogged, move the unit to a low dose rate area, if possible, and unclog it as follows:

   1. With the unit running and beginning at the point farthest from the unit, hand-over-hand the hose shaking it to dislodge any obstruction.

2. If this doesn't dislodge the obstruction, replace the hose. Experience shows that additional efforts significantly increases the radiological hazards, are not ALARA, and typically cost more than a new hose.
3. Replace the vacuum cleaner and hose with a unit that has a current aerosol test date.
4. If it is necessary to empty the debris from a vacuum cleaner or disassemble it to remove a blockage, it should be moved to an appropriate low radiation work area before disassembly. See Section 2.3.4 below.

g. When using tools to work on contaminated surfaces, it is desirable to position a HEPA filtered vacuum or ventilation hose near the work to reduce contamination spread and possibly reduce or eliminate the need for respiratory protection. Connection of a vacuum cleaner hose directly to a tool requires either a special containment, an attachment installed on the tool, or a specially modified tool that has a "shrouded" housing.

A conical shaped containment can be made by the PFP plastic shop (373-2220) to enclose the tool and have a sleeve for a vacuum cleaner hose. See Figures 6A, *PVC Conical Containment*, and 6B, *Commercially Available "Shrouded" Tooling*, for a sketch of this containment and an illustration of different types of shrouded tooling. There are several sources for specialized tooling that includes shrouding and/or vacuum connection for radiological work. Contact the ALARA Center of Technology at 376-0818 or 372-8961 for product information.

h. Radiation, contamination, and airborne monitoring is performed in the work area as part of monitoring the work area radiological conditions.

Note: The below radiation levels of 25 and 100 mrem/hr are suggested limits and were selected in order to provide some guidance so that the vacuum cleaner is not allowed to become a high radiation source without approval of radiological control personnel.

- Contamination surveys should include the vacuum cleaner exhaust port and seal areas to determine if contamination is leaking out of the vacuum or bypassing the HEPA filter.
- Dose rates of $\geq$5 mrem/hr at 30 centimeters require posting the area as a Radiation Area if not already accomplished.

Figure 3

Typical Vacuum Cleaner Installations

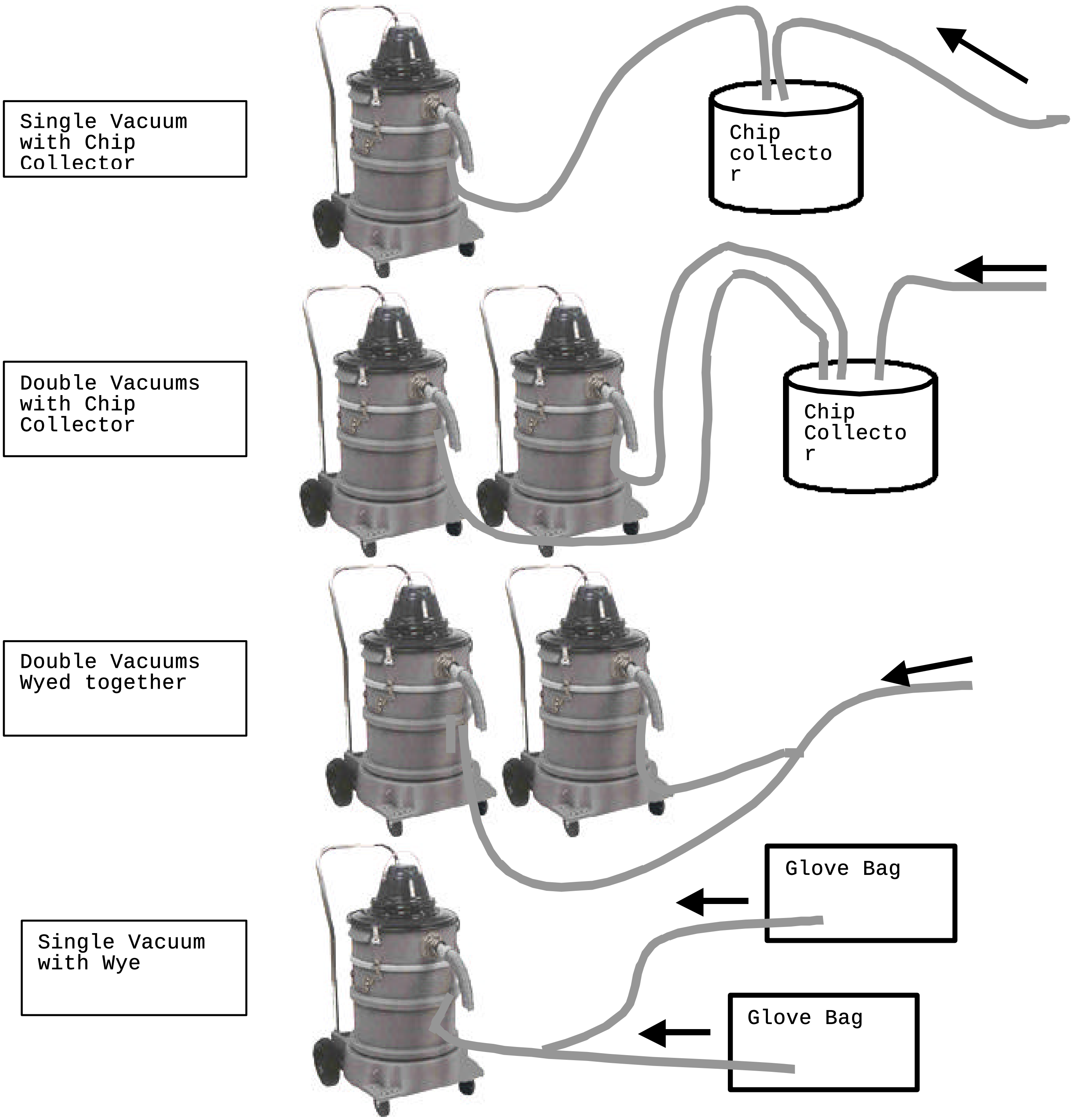


Figure 4

Velocity Flow Diagram

H. Flow Rates

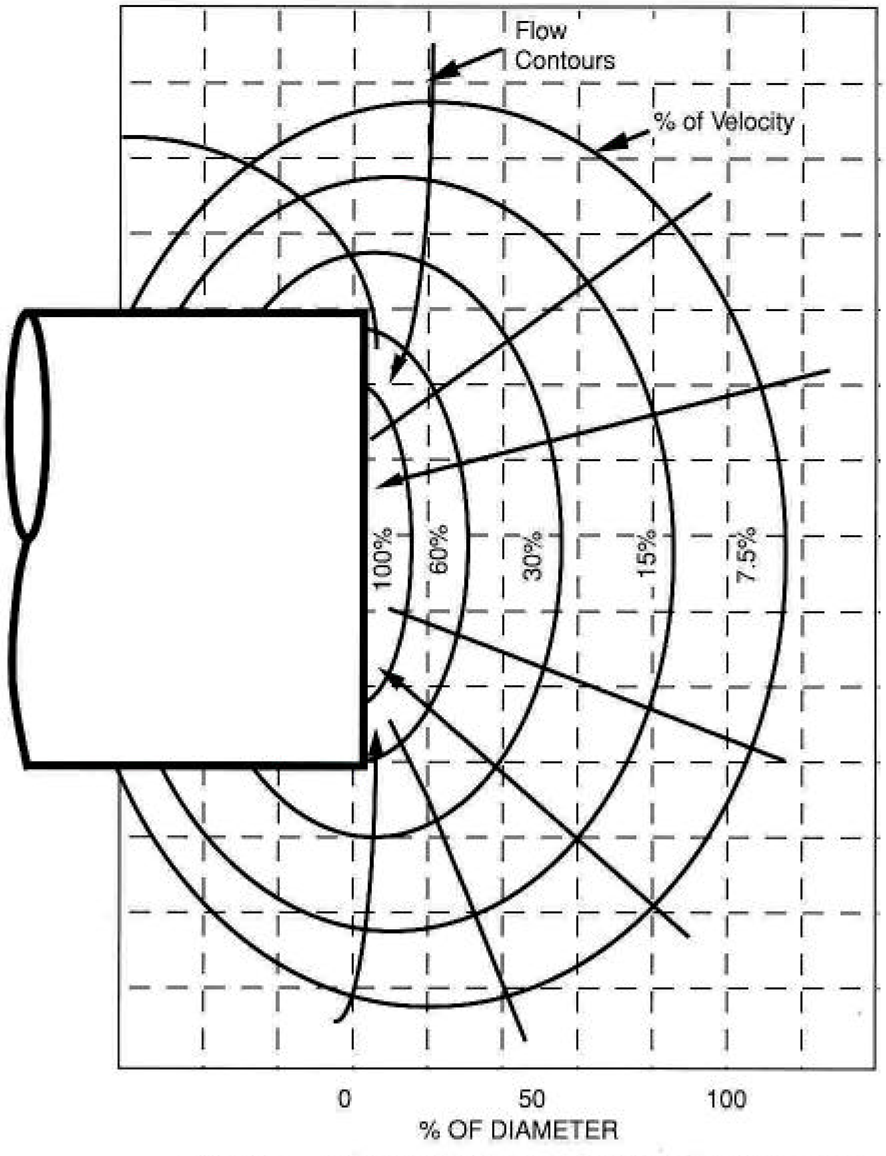
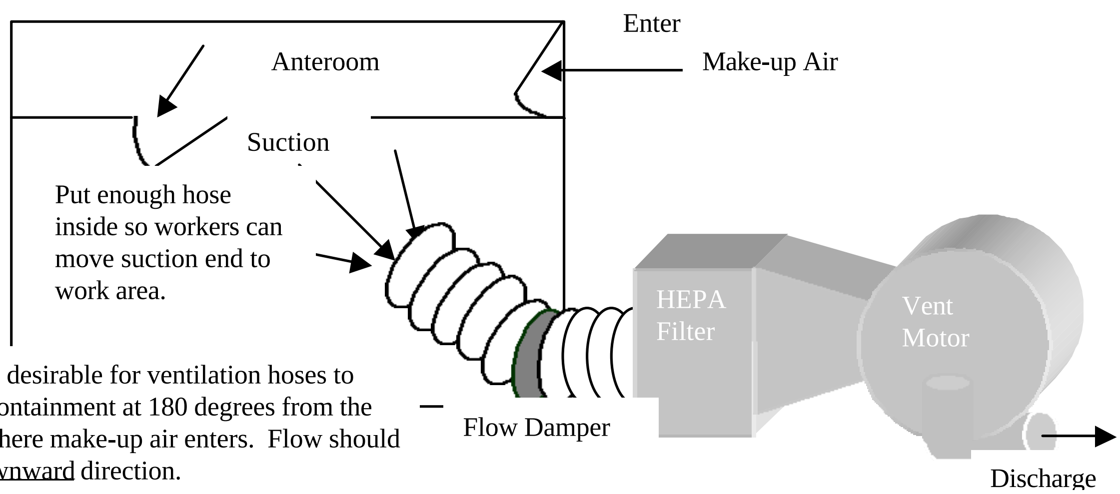


Figure Velocity Contours - Plain Circular Hose Inlet Opening - % of Opening Velocity

Figure 5A

Containment Tent Ventilation



Note: It is desirable for ventilation hoses to enter the containment at 180 degrees from the location where make-up air enters. Flow should be in a downward direction.

Figure 5B

Position of Localized Ventilation

Position suction end of hose 90-180 degrees away from worker at no more than 1 duct diameter away. This will draw airborne particulate away from the worker's breathing zone.

Place screen over the hose end to prevent hose plugging

For Example:
If hose is 6" diameter position it a maximum of 6" away from the source of contamination

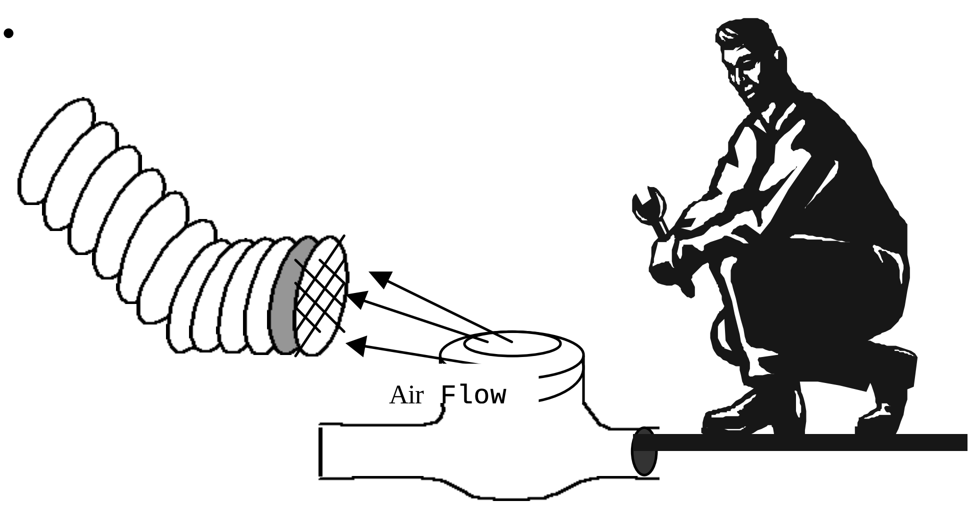


Figure 6A

PVC Conical Containment

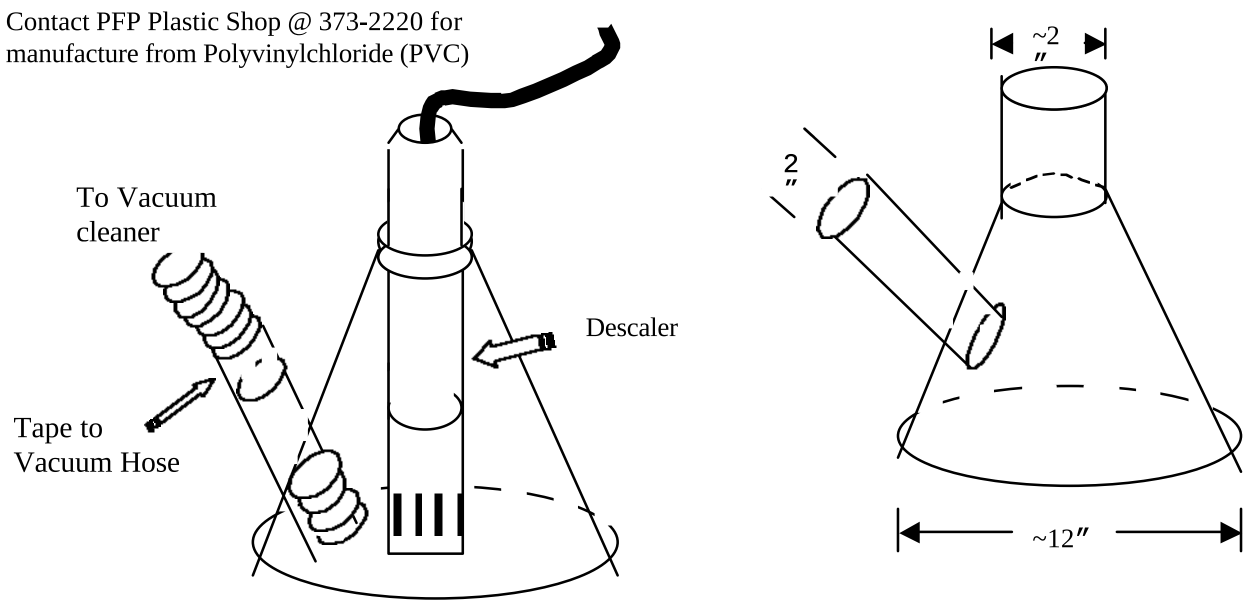


Figure 6B

Commercially Available "Shrouded" Tooling

- If contact radiation levels on the vacuum cleaner or ventilation system are increasing and it is likely they will exceed 25 mrem/hr or a lower limit specified in the RWP or technical work document, notify facility operations. Consideration should be given to removing the vacuum from service, while the dose rates are relatively low, and serviced prior to further use.

- If the RWP or technical work document authorizes the unit to be operated at a higher radiation level, consider rerouting the exhaust from the vacuum cleaner directly to controlled ventilation system or install another HEPA filter in the exhaust or suction line if the radiation level on the vacuum cleaner exceeds 100 mrem/hr on contact. This will aid in assuring the discharged air will not exceed airborne radioactivity limits for non-Airborne Radioactivity Areas.

- Radiation levels should be maintained much lower if the vacuum cleaner is collecting Plutonium contamination since the gamma radiation is lower energy. Do not allow the radiation level on the vacuum cleaner to exceed the limiting condition of the RWP or the upper limit of the posted area.

- The RCT should update dose rate information on the existing Radioactive Material Control Tag or attach a new tag if needed.

i. If a vacuum cleaner is being used to collect low-level radioactive waste, it should not be used to collect "mixed" or TRU waste also, or the entire contents will have to be treated as mixed or TRU waste. If possible, use two vacuum cleaners or other methods to segregate these materials.

j. Any vacuum cleaner found with seals broken or other evidence of tampering shall be removed from service and the vacuum cleaner inspected. An efficiency leak test must be performed prior to use.

k. Operating Precautions:

NOTE: Some vacuum cleaners have thermal protection devices. Some do not.

- Do not operate electrical vacuum cleaners for long periods with the end of the suction hose bagged. In addition to damaging the components, overheating the vacuum cleaner motor could result in a fire.

- Most electric vacuum cleaners should not be used to vacuum explosive gases or flammable/combustible liquids. Special non-sparking explosion-proof vacuum cleaners or pneumatically operated vacuums can be used for this purpose.

2.3.3 Radiological Vacuum Cleaner Movement

Note: This SD does not discuss any applicable controls for DOT transportation.

a. If the vacuum cleaner was used in a Radiological Buffer Area (RBA), it is possible that very small quantities of radioactive material can accumulate on the upstream side of the HEPA filter so it should be monitored upon disassembly to determine if it must be treated as radioactive material.

b. When contaminated vacuum cleaners are transported between controlled areas, the hoses should be removed from the unit and bagged or capped to prevent spreading contamination. If the unit is being repositioned within a contaminated area, the hoses should not be removed unless required due to interferences.

c. When disconnecting a hose, the system should be in an established contamination area, operating and a plastic bag or equivalent held under the connection. Don necessary protective clothing and, with permission from an RCT, untape or disassemble the connection as required and remove the hose. Bag the hose/vacuum cleaner and have the RCT perform required radiological monitoring. Removal of chip collectors and in-line HEPA filters are accomplished in this same manner.

2.3.4 Disassembly and Emptying of Contaminated Vacuum Cleaners

Vacuum cleaners should be opened for repair, filter replacement, or emptying using the following radiological protection guidelines:

Note: These requirements are generic. Radiological workers who disassemble and empty vacuum cleaners should consult with line management and the cognizant Radiological Engineer for direction on cleaning procedure variations based on the type of vacuum cleaner. Project/Activities should have their own work procedures and RWPs that provide the work steps and radiological controls for this change-out.

a. A Radiological Hold Point should be included in the technical work document that verifies specified radiological controls are in place just prior to opening the vacuum. Verification that an engineered enclosure is surrounding the unit to contain potential contamination and/or appropriate air controls and monitoring are established is an example.

b. Notify Industrial Hygiene/Safety Engineer if mixed or TRU waste are involved.

c. The disassembly should be accomplished in a specially designed glove bag or inside a containment tent or room located in a low radiation area.

- The containment or room should include complete physical boundaries to isolate it from surrounding areas and should be equipped with HEPA-filtered ventilation.

- Other engineered or administrative controls should be used as necessary to minimize the potential for internal exposure.

d. Personnel involved in emptying vacuum cleaners should be specifically instructed in procedures and radiological control requirements for this task.

- Since the debris may be highly radioactive and/or hazardous, extreme care should be exercised during this operation.
- Radiation/contamination monitoring should be performed prior to and during opening of the unit.

e. Airborne radioactivity samples should be taken during the work and additional provisions, such as a continuous air monitor, used to inform workers if elevated levels of airborne radioactivity are encountered.

f. Protective clothing for opening a HEPA-filtered vacuum cleaner will be specified on the RWP and may include respiratory protection if the work area is outside of a glove bag or glove box and other engineered or administrative controls may not prevent airborne radioactivity.

g. Methods typically used to contain contamination during the cleaning include:

- Wrap the vacuum cleaner in plastic prior to opening to prevent contamination from contaminating the external surfaces. Do not enclose the seal areas that will be opened during emptying or replacement of the HEPA and other filters/bags. This plastic should prevent the vacuum cleaner from becoming contaminated on its external surfaces.

- "Mist" the vacuum cleaner canister with water during removal of the prefilter, HEPA filter, and collection bag to contain the radioactive debris and reduce airborne contamination. Do not spray the HEPA filter if it is not going to be replaced. A "windex" type bottle filled with water works well for this "misting."

- Use damp rags to wipe down the accessible surfaces inside the vacuum cleaner as soon as it is exposed during opening.

- Use care to avoid puncturing or compressing the collection bag as it is removed and placed into a plastic bag.

- If the vacuum cleaner has to be separated at a location that compromises the seal on the HEPA filter, ensure the aerosol leak test sticker is broken so that the unit will have to be retested before future use.

- Once the vacuum cleaner is reassembled, decontaminate the plastic material installed on the external surfaces before it is removed. Perform contamination monitoring as required.

h. When the vacuum cleaner has been emptied and a new collection bag installed, reattach the collection canister and install new security seals on the latches.

Note: Training or procedure validation for emptying of vacuum cleaners can be accomplished at the ALARA Center.

2.3.5 Efficiency Testing of Vacuum Cleaners

a. New vacuum cleaners are normally tested at the Test Facility located in Building 2101M in 200E. Contact Vent and Balance at 373-4866.

b. Once a vacuum cleaner becomes radioactively contaminated, the retesting of the HEPA filters is accomplished at each facility. The most cost-effective method is to assemble several vacuum cleaners in one location before contacting Vent and Balance to come to the facility. Vent and Balance personnel have the necessary training to enter radiological areas and perform the aerosol testing in-place, if necessary. If the vacuum cleaners need servicing or repair, this work should be accomplished before the aerosol testing.

2.4 Air Quality Environmental Guidelines For Using HEPA Filtered Vacuum Cleaners

This section contains additional guidance that may apply to vacuum cleaner operations. The following is a summary of the work controls for the activity. Detailed requirements are located in the DOE/RL-97-50, Rev. 2, and associated approval conditions (letter, A. W. Conklin [DOH] to S. Wisness [RL], Correspondence No. 0201147, AIR 02-303, dated March 5, 2002).

2.4.1 Routine Uses Exempted from Air Quality NOC

a. Use of small pistol-grip type handheld HEPA vacuum cleaners used to clean up spot surface contamination areas found during outdoor radiological field surveys and to clean up localized radiologically contaminated material (e.g., dust, dirt, bird droppings, animal feces, liquids, insects, spider webs, etc.).

b. HEPA vacuum use for established routine work at an existing facility whose stack is registered with the WDOH and the emissions from the vacuum are vented through that stack.

c. Use of HEPA filtered vacuums that are described as part of an activity identified in a separate, existing NOC also are excluded.

2.4.2 HEPA Vacuum Uses and Limitations (approved in accordance with the NOC [DOE/RL-97-50, Revision. 1]).

a. HEPA vacuum exhaust flow rates may range from 50 to 300 cubic feet per minute.

b. HEPA vacuums used for the reduction of smearable contamination from hard surfaces.

c. HEPA vacuums used to reduce fixed contamination involving the removal and/or penetration of contaminated surfaces, not including soil matrices. This category of use includes using HEPA vacuum units and associated shrouded tools for sanding, stripping, spalling, drilling, and cutting operations.

d. HEPA vacuumed surfaces may not exceed an average of 2,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) alpha contamination and 100,000-dpm/100 cm^2 beta/gamma contamination. An exception to these limits is restricted to spot surface contamination areas found during outdoor radiological field surveys and to clean up localized, radiologically contaminated material (e.g., dust, dirt, bird droppings, animal feces, insects, spider webs, tumbleweed fragments, etc.). These types of materials could have beta/gamma contamination levels exceeding 1 million dpm/100 cm^2, but are very localized (i.e., a few square meters rather than hundreds of square meters) and could occur in contamination areas, buffer zones, and clean zones. This exception does not apply to areas normally posted as high contamination areas.

e. The table in Appendix A, *Use of HEPA Filtered Vacuum Cleaners Used on the Hanford Site*, provides a listing of the HEPA vacuum units included in the scope of the NOC. The list of HEPA filtered vacuum cleaner units in Appendix A is current as of the date of issue of this document. Contact the Hanford ALARA Center for the latest edition of this list.

f. The table in Appendix B, *High-Efficiency Particulate Air Filtered Vacuum Unit Associated Tools For Radioactive Contamination Removal*, provides a listing of HEPA vacuum assisted (shrouded) power tools. The list of HEPA filtered vacuum unit associated tools in Appendix B is current as of the date of issue of this document. Contact the Hanford ALARA Center for the latest edition of this list.

g. HEPA vacuums may be used for void reduction, such as when the air is removed from glove bags following use or from plastic-wrapped, low-level radioactive waste for disposal. A smear of the interior surface of the glove bag is taken and the estimated curie contamination on the surface of the glove bag can be used as described in Appendix C of the NOC to assure the limits for contamination are not exceeded. As stated in the NOC approval conditions, the Washington State Department of Health may require a nondestructive analysis/assay (NDA) of the HEPA filter after each exhaust job assignment.

h. HEPA vacuums may be used to collect exhaust air from a pipe that is being swiped with a sponge type ball to verify that the pipe can be released as nonradiologically contaminated. A smear of the interior surface of the glove bag is taken, and the curie contamination estimated as described in Appendix C of the NOC to assure the limits for contamination are not exceeded.

2.4.3 Periodic Confirmatory Monitoring to Verify Low Airborne Emissions

The method used for monitoring is the log sheet, containing at least the below information that is used to track HEPA vacuum use and the calculations to determine maximum expected annual emissions. When implementing the use of HEPA vacuums, the responsible personnel (operators) log the following information. Additional information can be tailored for the individual facility.

- Location of operation and make and model of unit

- Date(s) of operations
- Purpose of operation (or work package number)
- Air emissions source constituents (if other than plutonium-239 and strontium-90)
- Area cleaned (in square meters)
- Maximum contamination level encountered or analysis results
- Potential radionuclide releases
- Results of smears on the exhaust port(s) positive (in dpm/100 cm^2) or negative

2.4.4 Reporting to Washington State Department of Health

All HEPA vacuum logs sheets shall be submitted to the Washington State Department of Health on a quarterly basis.

2.4.5 HEPA Filter Efficiency Testing

The collection efficiency testing required by the NOC is addressed by the requirements provided in Section 2.3.5 above.

2.4.6 Notifications to Washington State Department of Health

If a new type of HEPA vacuum unit is acquired for use, the Washington State Department of Health must be notified at least seven days prior to any planned preoperational testing of the first new unit of that type to be placed in service.

Also, the 24-hour notification requirements, as provided in HNF-PRO-453, *Spill and Release Reporting*, must be met for HEPA vacuum units.

3.0 USE OF HEPA FILTERED PORTABLE VENTILATION SYSTEMS

The following guidelines apply to the installation, operation, and removal of portable HEPA filtered ventilation units installed to reduce the spread of contamination during radioactive work. Final installation of temporary or permanent ventilation systems requires coordination with the Project/Activity Environmental representative. Portable ventilation units are normally used to provide negative ventilation in radiological contaminated areas and airborne radioactivity areas.

3.1 System Description

A HEPA filtered portable ventilation system consists of a composite unit that includes a blower, filters, and connecting plenums, motor control switches, flow control devices, and differential pressure gauges. The components of a typical HEPA filtered portable ventilation system are shown in Figure 7, *Typical Portable HEPA Filtered Ventilation System*.

a. The first major component the contaminated air passes through is a prefilter that collects the larger particulates.

- The prefilter is normally a shallow, tray-like assembly containing course fiber media (glass, cotton, synthetics) or a crimped metal mesh enclosed in a steel or cardboard casing.

- The media, or mesh, is coated with a tacky oil, or adhesive, to improve retention of trapped particles. Particulate removal efficiency ranges from 2 percent for 0.3 micron particles to over 90 percent for 10 micron particles.

- Pressure drop at rated flow across the prefilter normally ranges from 0.1" water gauge (wg) when clean to 0.5" wg when depleted.

- It is better to replace prefilters than to replace other filters in the system because prefilters are the least expensive, and changing the prefilter may not effect the system efficiency test (aerosol test).

- For situations where heavy dirt or moisture accumulates on the filter, special prefilters/demisters may be grouped in a series to provide extra ability to remove contaminants and protect the downstream filters.

b. High Efficiency Particulate Air (HEPA) filters are the second major component in the system and are used to remove small particulates. HEPA filters are 99.97 percent efficient or better for removing 0.3 micron particles at rated flow.

- The filter rating should be at the 0.3 micron median diameter size since particles of this size are the most difficult to capture.

- This filter also captures particles in the 0.05-micron to 5 micron range, which are the primary concern in operations involving radioactivity since these particles tend to be retained by the lungs.

- HEPA filters consist of an external rigid casing usually made from metal or wood with folded, paper-like filter media attached inside by special adhesives. Metal mesh hardware cloth protects the delicate filter media and prevents damage during handling.

- Figure 8, *Typical HEPA Filter*, shows how a HEPA filter is constructed. Gaskets are used for sealing the HEPA filter into the filter housing and must be extremely efficient to prevent the passing of airborne contaminants around the filter.

- The differential pressure drop across a new HEPA filter is normally 1" wg or less at filter rated airflow.

- HNF-5173, Article 464.2, specifies that the maximum flow rate of the system shall not exceed the flow rate at which the HEPA filter was efficiency tested.

c. In addition, a carbon adsorber could be installed in the system to remove radioiodine gas. Since the present mission at Hanford does not include operating reactors or the reprocessing of nuclear fuel, radioiodine gas is not a concern. If radioiodine became a concern in the future, carbon adsorbers could be used to remove radioiodine gas from the air stream. All carbon adsorbers are rated at a given air flow with corresponding residence time (time the iodine is in contact with the adsorber). Carbon adsorbers consist of a rigid external casing with a perforated sheet inner casing filled with activated carbon. Activated carbon is an effective adsorber because of the large surface area. One pound of activated carbon has a surface area from three to nine million square feet. HEPA filters should always be installed upstream of the adsorber to prevent early depletion of the adsorber due to dust accumulation. Since carbon adsorbers cost five to six times more than HEPA filters, protecting the carbon adsorbers is cost-effective. HEPA filters downstream of carbon adsorbers are also recommended to collect any radiological charcoal fines released from the adsorber.

d. A blower, consisting of a fan and electric motor, is the source of energy that creates a static pressure, causing air to flow through the system. As the fan rotates, air is drawn through the system and particulate is deposited on the prefilters and HEPA filter. The discharged air can either exhaust directly from the blower or a portion of the air can be recirculated back into the work area through hoses or ducting. If the portable ventilation system is operated in areas where temperatures are very cold or very warm, it is possible to add a heater or cooler to this recirculation line to improve working conditions.

3.2 System Design Parameters

a. Because portable ventilation systems must be compact, design for optimum performance is not always possible.

- Gradual taper on the filter inlet and outlet and a long straight inlet to the fan are ideal but not practical since the unit would be excessively long; therefore, some compromise must be made between optimum design and size.

- Flat plenums, with no taper, should be avoided because they channel flow only through the center of the filter, which results in excessive pressure drop.

- Tapered plenums upstream and downstream provide the best results, alternately; space for air expansion and high performance blowers will substitute for a lack of inlet taper at an overall loss of optimum performance.

- Differential pressure gages across the prefilter/HEPA filter are recommended to indicate filter loading. The gages should have a range from 0" wg to 6-10" wg. A high pressure reading on the gage indicates that the filter should be replaced. Adjustable dampers should be installed in the outlet of the portable ventilation system to regulate system flow.

Figure 7

**Typical Portable HEPA
Filtered Ventilation System**

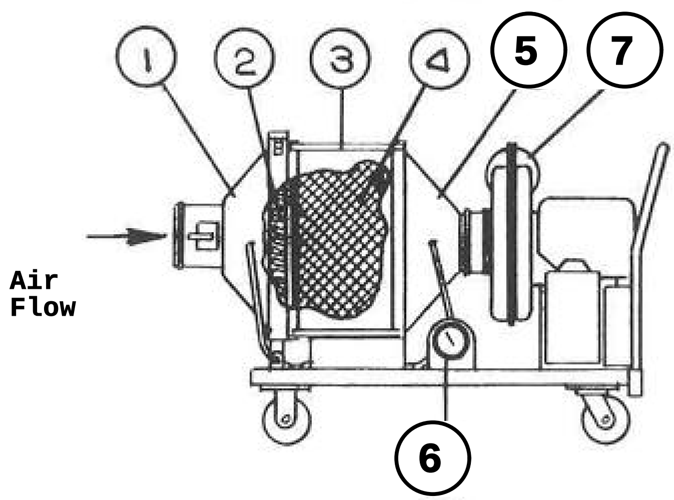
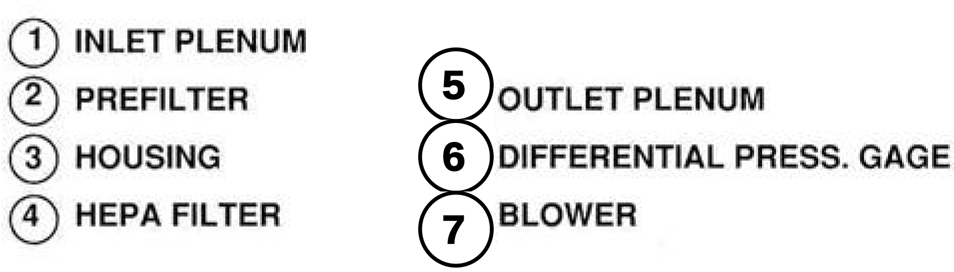
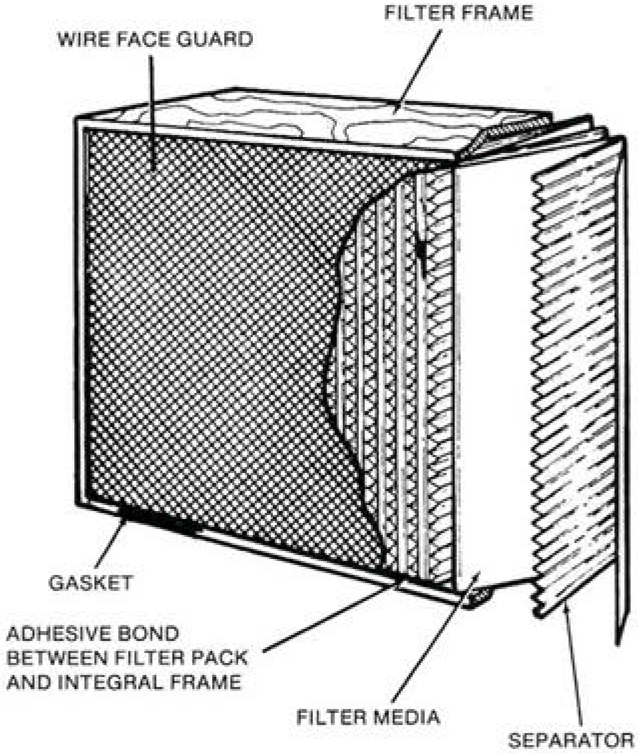


Figure 7. Typical Portable HEPA
Filtered





- **Efficiency is 99.9%**
- **Type A, B, and C filters**
- **Design features shown**
- **Change-out due to:**
  - **Radiation Levels**
  - **Differential pressure**
  - **Inadequate flow**

Figure 8. HEPA Filter

b. System Pressure Drop: The ability of the system to move air at a given rate depends upon the fan and the pressure loss through the system. System pressure loss is composed of fixed losses (at constant flow) and variable losses.

- The fixed pressure loss is the loss through installed ducting, transitions, filter housing (minus the filters), fan, and inlets and exits.

- Variable pressure losses are losses through flexible hoses (may be added to the system to ventilate distant areas), prefilters, and HEPA filters (as they become loaded with dust).

- When choosing a portable system, ensure the fan can develop high static pressures (the measure of force exerted by the fan to move air through the filtration system). This allows the addition of long; flexible hoses for suction in remote work areas and provides sufficient differential pressure across the filter before it must be changed.

c. Fans and Blowers: Special consideration must be given to selecting a fan for portable filtration equipment.

- The fan must have flow characteristics that allow it to operate over a large pressure range to account for inherent system losses and increased pressure drop as filters collect dirt.

- If the fan is inadequate, less than rated flow will occur as the filters become clogged, requiring premature filter replacement.

- Centrifugal fans with backward inclined blades are best suited for flow rates up to several thousand cfm. The fans are non-overloading and provide high static pressure over a large operational range of flow.

- Direct drive fans offer more compact design and reliable service, but belt-driven fans are also acceptable.

- Fans driven by three-phase motors should always be checked for proper direction of blade rotation when power is connected. When running backwards, the fan discharges some air, but only a small portion of the rated flow is produced.

- Fans should always be located downstream of all filters to maintain negative pressures in the filter housing and keep the fan clean. In this way, any air leakage in the contaminated portion of the system is inward, preventing release of contamination.

- In some applications, fans and blowers may have to be located in outdoor or moist locations and consideration needs to be given to electrical safety requirements.

d. Flow Rates: The air flow rate, or velocity, into a hood or work area when using portable ventilation is characterized by the capture velocity and duct velocity. Table 1, *Range of Capture Velocities*, provides some typical velocity ranges.

- Capture Velocity: Air velocity at any point in front of a hood or at the hood/hose opening necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the hood/hose.

- Duct Velocity: Air velocity through the duct cross-section. When solid material is present in the air stream, the duct velocity must be equal to or greater than the minimum air velocity required to move the particles in the air stream.

Note: Capture velocity varies, depending on the size of the particles and the rate at which they are released into the air. For most situations, 150-200 feet per minute (fpm) capture velocity is satisfactory. This will be the minimum flow necessary to move the particulate into the hose rather than be spread in other directions.

TABLE 1. Range of Capture Velocities

Dispersion of Contaminant	Examples	Typical Capture Velocity (fpm)
Released with practically no velocity into still air	Evaporation from tanks	50-100
Released at low velocity into moderately moving air	Welding, spraying booths, intermittent container transfer, hand tool work on contaminated items	100-200
Active generation into rapidly moving air	Spray painting, barrel filling	200-500
Released at high velocity into very rapidly moving air	Grinding, abrasive blasting	500-2000

Notes:
1. For most situations, 150 to 200 feet per minute (fpm) capture velocity is satisfactory.
2. For ventilating work areas, 7 to 12 room volume air changes per hour are recommended. (Some facilities have established their own parameters with air changes up to 20 per hour.)

   - To calculate the flowrate for a room, use this example: a 10' x 10' x 10' room has a volume of 1000 ft^3. At 12 changes per hour, this is equivalent to:

     $$1000\ ft^3 \times \frac{12\ changes}{hour} = 12{,}000\ ft^3 \text{ per hour}$$

     Converting to normal flow rate units of cubic feet per minute (cfm) results in:

     $$12{,}000\ ft^3 \text{ per hour} \times \frac{1\ hour}{60\ min} = 200\ cfm$$

- To conserve thermal energy, recirculate discharge air through the filter system back to the work area/room, discharging only a small portion (typically 15 percent) of air to the environment. A path for make-up air to enter the ventilated area must be provided to compensate for any air discharged. This recirculated air may reintroduce contaminants that are not removed by the HEPA filter back into the space.

- Radiological and/or hazardous work areas should be planned so that air moves from the least contaminated to progressively more contaminated areas before finally entering the ventilation suction. This flow path prevents cross-contamination of the work areas. Maintaining a differential pressure of at least 0.10” wg between work areas can also prevent cross contamination. Do not allow the differential pressure to become so great that the negative pressure collapses the work area (e.g., a containment tent). Sufficient make-up air must be provided to the work area to prevent collapse.

- Approximate flow rates and velocity may be determined using the following formula:

  V = Velocity (in linear feet per minute)
  A = Area of opening (in square feet)
  F = Flow rate (in cubic feet per minute)

$$V = \frac{F}{A} \qquad F = V \times A$$

- Additional information on air flow associated with the use of portable HEPA filtered ventilation systems are shown in Tables 2, 3, and 4.

TABLE 2. Effective Distance of Capture Velocity For 500 cfm HEPA Filtration System

Hose Size (inches)	**VELOCITY IN FEET PER MINUTE**						
10	925	429	164	81	-	-	-
8	1420	512	175	84	-	-	-
6	2600	613	186	86	-	-	-
4	5500	699	193	88	-	-	-
	Face	3"	6"	9"	12"	15"	18"
(DISTANCE FROM END OF HOSE ON CENTERLINE AXIS)							

Rule of Thumb for Capture Velocity is a minimum of 150 fpm.

TABLE 3. Effective Distance of Capture Velocity for 1000 cfm HEPA Filtration System

Hose Size (inches)	VELOCITY IN FEET PER MINUTE						
10	1850	858	329	162	95	62	-
8	2850	1025	350	167	95	62	-
6	5200	1226	372	172	98	63	-
4	-	-	-	-	-	-	-
	Face	3"	6"	9"	12"	15"	18"
(DISTANCE FROM END OF HOSE ON CENTERLINE AXIS)							

Rule of Thumb for Capture Velocity is a minimum of 150 fpm.

TABLE 4. Effective Distance of Capture Velocity for 2000 cfm HEPA Filtration System

Hose Size (inches)	VELOCITY IN FEET PER MINUTE						
10	3700	1716	658	325	190	123	87
8	5700	2050	701	335	193	125	87
6	10,500	2454	744	344	196	126	88
4	-	-	-	-	-	-	-
	Face	3"	6"	9"	12"	15"	18"
(DISTANCE FROM END OF HOSE ON CENTERLINE AXIS)							

Rule of Thumb for Capture Velocity is a minimum of 150 fpm.

e. Aerosol testing: After the filters are installed in the system/housing, trained personnel using Facility Maintenance Procedure 7-GN-059 perform an aerosol test.

- An aerosol having a mean particle size of 0.7 micron is used.
- The field-testing equipment usually consists of a unit to generate the aerosol and a unit to measure the system's efficiency in removing the aerosol.
- While the system is running at its normal flow rate, the aerosol is injected into the system upstream of the HEPA filter. The detection apparatus takes a sample of air from the upstream side of the HEPA filter and is adjusted to read 100 percent concentration. Then,

a sample of air from the downstream side of the HEPA filter is taken. The downstream reading is the percent penetration through the filter. System efficiency is calculated by subtracting the percent penetration from 100 percent.

3.3 Ideal Portable HEPA Ventilation System

An ideal portable ventilation system has the following characteristics:

1. The ALARA Center recommends that facilities purchase high-quality "Nuclear Grade" ventilation blowers equipped with a HEPA filter if it is going to be used for radiological work. There are several companies that sell inexpensive units that might be all right for asbestos, but don't work well for radiological work. The fan should have flow characteristics that allow it to operate over a large pressure range to account for inherent losses in the system and increased pressure drop as the filters collect dirt and debris.

2. The length of hose or duct from the blower/fan to the work area should be as short as possible and contain a minimum number of bends.

3. The ducting should be routed through low traffic areas where it is protected to avoid damage.

4. The ducting should have no sharp bends. Usually, bends have a minimum radius of 2 to 2.5 times the duct/hose diameter. A straight duct section of at least six equivalent duct diameters should be used where the hose connects to the fan.

   NOTE: As a rule, a 90-degree bend is the equivalent of adding extra hose equal to 6-8 times the hose diameter.

5. The hose/duct has a smooth bore and is free of obstructions, especially at joints.

6. The hose/duct should be round whenever possible to reduce system losses.

7. Use of blast gates or other types of dampers should be avoided. If a blast gate must be used to adjust the flow, place it in a vertical section near the midway point. Install a tamper proof device.

8. The flow rate at the point where airborne contamination is captured is sufficient to cause the particulate to follow the air stream into the ventilation. This capture velocity is recommended to be a minimum of 150-200 feet/min for the type of work to be performed. If the airborne activity is released into quiet air, a capture velocity of 50-100 feet/min is all that is necessary. If grinding is performed, the particles will have a high initial velocity so the capture velocity of the ventilation needs to be in the 500-2000 feet/min range. A significant improvement in the amount of debris captured by the vent system can be attained if the suction hose is positioned so that the grinding particles flow directly into the hose.

9. Use of a funnel, scoop, or hood attached to the hose/duct to collect airborne contamination will increase the amount of contamination collected over a "hose only" application. The

design of the funnel or scoop forces incoming air to be drawn through the area where contamination is being created. Any particulate that is present is more likely to be captured in the air stream and carried into the vent system.

10. Position localized ventilation so that any airborne particles are drawn away from the worker's breathing zone. Normally, the ventilation sucker is placed 90 to 180 degrees from the worker on the opposite side of the source at a distance of one duct diameter, or less. If the suction end of the hose is greater than one duct diameter away from the source, very little contamination will be captured in the airstream.

11. System fittings should be designed so there is a gradual taper on the HEPA filter inlet and outlet and a long straight inlet to the fan. Transition pieces that change from one dimension to another should also be tapered. Since tapered connections on each side of the HEPA filter would require more space, you often find there is little or no taper.

12. Joints in the system should be securely sealed to avoid leaks.

13. If the system is going to draw moist or damp air, install a demister filter to remove the moisture before it reaches the HEPA filter. Damp HEPA filters lose their tensile strength and could fail if they become stressed later; i.e., during a fire.

14. Locate the ventilation system components in well-lighted areas that allow easy access for maintenance.

15. Air discharged from the blower tends to flow in a straight line. If you measure the flow at the discharge point and call that 100%, then you will still find 10% of the flow at a distance of 30 times the diameter of the discharge. Ensure the air being discharged does not disturb contamination or asbestos that might be present in the work area. This may require installing a vent hose on the discharge side of the blower and either pointing it up or routing it outside the work area.

16. If the system is going to be used for hot work, a metal hose with a spark arrester is needed to avoid causing a fire in the flex ducting and/or prefilter/HEPA filter.

17. After a ventilation system is installed, contact Vent and Balance at 373-5083 or 373-4866 to accomplish an aerosol leak test. This will ensure the HEPA filter is installed correctly.

18. The industry standard for air changes in a containment tent is 7-12 air changes per hour. In the nuclear industry, air changes up to 20 per hour are common. The important thing to consider is the amount and direction of flow at the source of contamination. So if you are removing a flange from a contaminated system inside containment, look at what the ventilation is doing at the flange. Powdered material can be blown near the flange and you can determine the direction and make an estimate whether existing controls are adequate. The Hanford ALARA Center recommends that facilities purchase a product similar to Flowchecker® Silica Powder, Item 7904C from Lab Safety Supply, Inc. at (800) 356-0783 or www.labsafety.com.

® Flowchecker is a trademark of Lab Safety Supply, Inc.

3.4 PHMC Requirements For Using Portable Ventilation Systems:

3.4.1 Requirements:

There are several mandatory requirements that must be followed to use portable ventilation systems for radiological work. These requirements are located in HNF-5173, Article 464, and HNF-RD-8703, *Air Quality-Radioactive Emissions*, that specifies adherence to the mandatory requirements associated with the DOE/RL-96-75, Rev. 2, *Radioactive Air Emission Notice of Construction – Portable/Temporary Radioactive Air Emission Units.* Additional information to support implementation of these requirements is provided below.

- Personnel who are considering installing a HEPA filtered portable ventilation system outside or in a facility that does not have a building HEPA filtered exhaust system should review the Notice of Construction (NOC) documented in the DOE/RL-96-75, Rev. 2, and the associated approval conditions issued by the Washington State Department of Health (letter, A. W. Conklin [DOH] to J. B. Hebdon [RL] and J. E. Rasmussen [RL], AIR 99-1102, dated November 4, 1999).

3.4.2 Specifications:

The specifications used at Hanford for the procurement of these filters are:

- WHC-S-0462, "Specification for Procurement of Portable Nuclear Grade HEPA Filtered Vacuum Cleaners and Replacement Filters"

- WHC-S-0463, "Specification for Procurement of Portable Exhaust Equipment and Replacement Filters"

Note: ASME AG-1, Section FC, superseded Mil-51068.

3.4.3 Environmental Requirements:

HNF-RD-8703 - Specifies required compliance with the descriptions and approval conditions associated with the DOE/RL-96-75, Rev. 2. The requirements of the NOC do not apply to portable ventilation systems that exhaust inside facilities that have a HEPA filtered ventilation system. Operators of these systems should log information the responsible organization determines necessary.

3.4.4 Labeling:

Labeling is accomplished as follows:

- Unit and upstream hoses/ductwork should have a Potential for Internal Contamination Label and the unit has a Radioactive Material Tag (See HNF-5173, Chapter 2).

- Unit should have a current efficiency test sticker attached and the unit should have been tested within the last six months.

NOTE: The six-month requirement of HNF-RD-8703 is more restrictive than the annual requirement of the PHMC Radiological Control Manual, HNF-5173, Article 464.

- If the six months will expire before the job is completed, have the unit tested or obtain another unit.

- If the unit is past due for retesting, remove it from service.

- The efficiency test sticker should be installed so that it will have to be torn to separate the unit at the HEPA filter seal.

In addition, inspect the unit to ensure Vent and Balance has installed the HEPA Filter Service Record Tag.

3.4.5 Aerosol Testing:

The frequency of aerosol testing should be increased if the portable ventilation system becomes highly radioactive and/or the system is exposed to hostile environments such as high moisture loading, chemical fumes, or is exposed to high temperatures.

3.4.6 Radiological Monitoring:

In addition to the requirements of HNF-5173, Articles 551 and 552.1, routine radiation monitoring should be performed in accordance with Project/Activity surveillances and applicable procedures.

Note: This should also apply to a vacuum cleaner if it is being used as a source of ventilation.

3.5 Guidelines For Using A Portable Ventilation System

3.5.1 Equipment Installation

a. The RWP should specify whether protective clothing (PPE) is required for handling radioactive portable ventilation system components and hoses/ducting. If the system is new and non-radioactive, the other non-radiological PPE requirements for the work area may apply.

b. The capacity of the exhaust fan should be included in the work package and shall be sufficient to maintain design flow rates throughout the range of dust loading to the HEPA filter and inherent system losses. The flow rate at the opening face of the hose or duct should be a minimum velocity of 1500-3000 feet per minute (FPM) to ensure the particles stay in the air stream until they reach the filters. Lower velocities will result in some of the particles falling out of the air stream and concentrating on the inside wall of the hose or duct.

c. Figures 5A, *Containment Tent Ventilation,* and 5B, *Position of Localized Ventilation,* show how a portable ventilation system is normally positioned for containment work. Section 3.3 describes an ideal portable ventilation system

- The filter housing and exhaust fan should be located outside the primary work area in an area that has adequate space around the unit to perform any required maintenance.

- A hose or ducting can either be connected from the prefilter housing through a containment sleeve and into the work area or the housing can be directly connected to a containment wall.

- A hose is attached and routed into the work area when it is desirable to draw suction near the location airborne contamination is being generated. Select a hose size that is larger than the source of contamination, whenever possible.

- Verify the capture velocity is great enough to capture the airborne particulate per Section 3.2. For best results, position the portable ventilation unit as close to the containment or work area as practicable in order to reduce the length of hose and the number of bends.

- If the hose must be bent, minimize sharp bends to reduce the pressure drop through the system.

- Do not route the hose through high traffic areas.

- Securely clamp and/or tape all joints to ensure they do not separate during work.

- In other cases, the technical work document may require the portable ventilation system be connected to the containment wall without a hose inside the work area. This is often done in containments at CHG that cover highly contaminated valve transfer pits in order to ensure that high levels of surface contamination are not "vacuumed" by the ventilation system.

d. When installing a ventilation hose or ducting into a containment tent, pull enough hose/ducting into the containment so the workers will be able to position it near the actual source of contamination. The hose/ducting should be made from materials that can be easily decontaminated or sleeved in plastic. Ideally, the suction hose should draw any airborne radioactivity away from the worker's breathing zone, assuming there is a minimum of 150-200 fpm capture velocity in the vicinity where airborne contamination is being created. Workers should position the end of the hose near the source of contamination at 90 to 180 degrees away from the worker.

Note: Figure 4, *Velocity Flow Diagram,* shows a diagram of velocity contours at the end of an open hose or duct. The distance to position the hose end from the source is recommended to be **<u>one times the diameter of the suction hose, or less.</u>** Additional measures can be taken to attach a "hood" or "scoop" to the end of the hose so that more airborne particulate will be captured by the ventilation system. In this manner, the ventilation will keep the contamination from spreading throughout the containment and reduce the area that becomes contaminated during work. When combined with other measures, e.g., covering contamination with fixatives or strippable paint, Radiological Control personnel may be able to reduce or eliminate the need for respiratory protection. If inert gas welding is required, the welders should determine how close the ventilation suction hose could be positioned in order to prevent the inert gas surrounding the weld area from being sucked away by the ventilation.

e. Consider the location of where "make up" air will enter the tent to replace the air being discharged. The entrance for make-up air is normally located at or near the personnel door, 180 degrees from where the ventilation hose exits the containment. This allows the make-up air to flow into the containment, past personnel in the anterooms, and into the work area. The make-up air should enter the containment through special filter media, HEPA filters, or dampers installed near the top of containment walls or doors at about head height. This creates a general downward flow of air towards the suction hose.

f. Visually check the entire system, including the hoses or ducting, to determine if there are any openings or breaks in the system. Hoses and extensions should be securely fastened to prevent the hoses from pulling loose while in use. Consider attaching a screen on the end of the suction hose to prevent large items from being sucked into the system. Locate the blower so the air exhausted will not cause turbulence in adjacent areas, which could spread contamination.

g. All components, fittings and hoses upstream of the HEPA filter are considered radioactively contaminated and should be marked and controlled as radioactive material in accordance with Section 3.3.l above. Components located downstream of the HEPA filter are not controlled as radioactive material, but should be monitored by an RCT when disassembled.

h. A portable ventilation system should not be used to remove moisture-laden air unless the system has a demister prefilter in front of the HEPA filter. The demister will remove the moisture so that it does not damage the HEPA filter. Normally, the demister has a drain hose connected to a radioactive collection system.

i. If the unit must operate continuously while the job is in progress, the facility should take actions needed to have an uninterrupted power source. Consider "Caution Tagging" or locking the electrical connections and switches. This will ensure the unit is not inadvertently secured during use.

j. If the ventilation system is going to be used on highly radioactive systems that will cause the HEPA filter to become highly radioactive, consider installing an in-line HEPA filter between the end of the hose and HEPA filter housing. Figure 2, *In-Line HEPA Filter*, shows an in-line filter assembly that can be made by adapting an existing HEPA filter used for other purposes to fit the suction hose. Highly radioactive particles deposited on the in-line filter prevent the system's main HEPA filter from becoming radioactive. The in-line filter can be replaced when it becomes highly radioactive or temporarily shielded until the job is complete. Replacement of the in-line HEPA filter does not affect the aerosol test on the main HEPA filter since it is being used as a prefilter. If possible, locate the in-line HEPA filter inside the containment tent, if installed, to make it easier to change out if it becomes too highly radioactive during use. Since this additional HEPA filter will be an added restriction to air flow, ensure the blower has enough capacity to provide adequate flow.

k. If the actual HEPA filter is visible, verify the flow arrows are pointed in the correct direction. The flow arrows are normally marked on the outside of the filter housing and designate the direction of airflow when the manufacturer initially tested the filter.

l. If the ventilation system is going to be used outside a facility and exhaust air directly to the environment without passing through an approved HEPA filtered stack exhaust system, permission may have to be obtained in order to use the system. Contact the Project/Activity Environmental representative.

- If the vacuum cleaner is being used to ventilate containment and it exhausts directly to the environment, personnel should verify that a permit is not required or is already in place.
- The requirement for a discharge permit also applies if the system is being set up in a facility that does not have a HEPA filtered building exhaust ventilation system; e.g., K Basins.

m. Portable ventilation systems used in contaminated areas should be protected from external contamination as much as practical, using techniques such as the following:

- Wrap the unit in plastic except for portions that will get warm during use and any motor air-cooling ports.
- Paint the unit with strippable latex decontamination paint prior to taking the unit into the contaminated area.
- Sleeve hoses and ducting.
- If the unit has wheels, apply tape over the tread area and sidewalls.

n. Once the ventilation system is installed or HEPA filters are replaced, contact Vent and Balance (373-4866) to perform an efficiency test. This test should not be confused with the efficiency test performed at the time of manufacture. HEPA filters tested by the manufacturer must be 99.97 percent efficient for stopping 0.3-micron particles at the rated flow. Once the HEPA filter is installed in the system, an efficiency of 99.95 percent is acceptable for polydispersed test aerosol of 0.7-micrometer median diameter. The 0.02 percent drop from the manufacturer's efficiency is attributed to both the difficulty of obtaining a 100 percent seal between the HEPA filter and the filtration system/housing and to the use of portable field equipment.

o. During initial set-up of the system, the work procedure may require a minimum flow rate in the containment. Vent and Balance personnel check the flowrate using special equipment at the inlet to the ventilation system and at the entrance to the room/containment. Vent and Balance personnel normally have smoke tubes or other products that can be used to evaluate the effectiveness of the ventilation. By blowing smoke in the work area near the suction hose, workers can determine the best location for the hose during different phases of the job. If the system is set up in a certified containment, contact Radiological Control and request a Radiological Control Technician be present during testing to simplify the containment certification process later.

p. Unless waived by vent and balance, retest a portable ventilation system each time it is moved and installed at a new location.

q. Once the testing is complete, a tag or sticker is normally attached to the HEPA filter housing in a location where it will be torn if the system is dismantled. If the connection is broken, the tag or sticker will be torn, and a new efficiency test will be required to be completed before the system can be used. Pertinent data and a signature are normally recorded on this tag/sticker to document who performed the test and the expiration date. On some portable ventilation systems, additional lead seals, cable ties, or other types of locking devices can be installed to prevent the inadvertent opening of the ventilation system.

r. If components of the ventilation system are located out-of-doors, install weather protection and protect the unit from damage from surrounding work activities; e.g., moving vehicles. Install temporary lighting if required.

s. Prior to operating the ventilation system, a logbook should be obtained to record necessary information. If the system exhausts directly to atmosphere without passing through a building HEPA filtered ventilation system, the required information needed for the logbook is defined by the Project/Activity Environmental representative in accordance with the applicable NOC (DOE/RL-96-75, Rev. 2). If the portable ventilation system is located inside a facility with its own HEPA filtered ventilation system, the responsible craft should determine what information is needed.

3.5.2 Operation of the Portable Ventilation Equipment

a. Protective clothing requirements for handling a contaminated ventilation hose will be listed on the RWP. Normally, the ventilation hose has its open end bagged in plastic or covered with metal or plastic caps when not in use. If the wrapping/caps have to be removed, the system should be turned on first so the suction will help control the spread of contamination as the hose end is uncovered. Extra care should be used when handling ventilation hoses as they become highly internally contaminated.

b. The HEPA filter is normally changed out when the system differential pressure does not improve with a new prefilter installed and/or radiological control establishes a maximum radiation level in the RWP that is lower than the limit in order to reduce personnel dose when handling highly radioactive filters.

c. During the conduct of work, radiation, contamination, and airborne radioactivity monitoring is performed in the work area as part of controlling the work.

- Contamination surveys taken on the ventilation system should include the hoses, connections, and the blower exhaust.
- If radiation readings of ≥5 mrem/hr are detected at 30 centimeters, post the area as a Radiation Area, if not already accomplished.
- If contact radiation levels on the portable ventilation system are increasing and it is likely they will exceed 25 mrem/hr or a lower limit specified in the RWP or technical work document, notify facility operations and recommend the unit be replaced.

d. If the RWP or technical work document authorizes the unit to be operated at a higher radiation level (identified during work planning), consider rerouting the exhaust from the ventilation unit directly to another ventilation system and/or install another HEPA filter in-line.

- See Figure 2, *In-Line HEPA Filter*, for an example of an in-line HEPA filter. This will ensure the air discharged will not exceed airborne radioactivity limits in non-Airborne Radioactivity Areas.
- Do not allow the radiation level on the ventilation system to exceed the limiting condition of the RWP or the upper limit of the posted area.

e. A method commonly used to track the effectiveness of a portable ventilation system requires marking one or more reference points on the external surfaces on the components. The Radiological Control Technician can then take contact dose rates as part of the required monitor. By monitoring the same location each time, it is possible to see increasing trends in radiation levels. These reference points are normally on the outside of the prefilter/HEPA filter housing and on the hose/ducting at low points or connections.

f. Precautions:

- Do not operate portable ventilation units for long periods with all dampers closed or damage to the fan, bearings, or filters may result.
- Do not insert your hand and/or foreign object into the fan housing as personal injury or damage could occur.

- If the ventilation system is being used to remove welding/burning smoke or grinding particles from a work area, consider installing a flame arrestor near the end of the metal ducting to ensure the system does not catch fire.

3.5.3 HEPA Filter Ventilation Systems Movement or Removal

a. When contaminated units are transported between controlled areas, the hoses should be removed from the unit and bagged or capped to prevent spreading contamination. If the unit is being repositioned within a controlled area, the hoses should not be removed unless required due to interferences.

b. When disconnecting a hose or breaking a connection, the system should be operating and a plastic bag or equivalent held under the connection. The following sequence is recommended:

- Establish a containment area.

- Don necessary protective clothing and with permission from an RCT, untape/unscrew the connection as required and remove the hose/ducting.

- Bag/cap the openings and have the RCT perform required monitoring

c. Removal of an in-line HEPA filter is accomplished in this same manner. When the entire ventilation system is being removed, start at the end of the system farthest from the vent fan and work towards the fan with the system operating. Any particulate that becomes airborne during the removal will be drawn away from the worker towards the HEPA filter.

3.5.4 Efficiency Testing of Portable Ventilation Systems

a. See Section 2.3.5

Appendix A
HEPA Filtered Vacuum Cleaners
Used on the Hanford Site

Make	Model	Flowrate (cfm)	Remarks
Kelly Decontamination System			
Hako[a] Minuteman	X-839	85-130	
Hako Minuteman	X1000-15	100	
Hako Minuteman	MX-1000	100	
Hako Minuteman	X-1000	130	
Hako Minuteman	MX-100	130	Wet and dry
Nilfisk[b]	GS-80 or GM-80	87	
Nilfisk	GS-82 or GM-82	191	
Nilfisk	GS-83 or GM-83	208-286	
Nilfisk	VT-60	99	Wet and dry
Nilfisk	Explosion Proof	130	Explosion proof/dust ignition proof
Nilfisk			Portable back pack
Nilfisk	CFM Model 127	190	
Nilfisk	CFM Model 137	286	Wet and dry
Power Products	RADPAC[c] 35	110	Hand carried
Power Products	RADVAC[c] 1500	180	
Power Products	RADVAC 2000	180	Wet and dry
Power Products	RADVAC 3000-SX or 3000-NX	270	SX-(stainless) NX-(painted)
Power Products	RADVAC 3500-SX or 3500-NX	270	Same as 3000 with secondary collection
Power Products	RADVAC 5000-SX or 5000-NX	201	Pneumatic 106 cfm required
Power Products	RADVAC 5500-SX or 5500-NX	201	same as 5000 with secondary collection
Power Products	RADVAC 6000-SX or 6000-NX	194	Pneumatic 152 cfm required
Power Products	RADVAC 6500-SX or 6500-NX	194	same as 6000 with secondary collection
Power Products	RADVAC 7000-SX or 7000-NX	187	Pneumatic 187 cfm required
Power Products	RADVAC 7500-SX or 7500-NX	187	same as 7000 with secondary collection

Make	Model	Flowrate (cfm)	Remarks
Euroclean	UZ-930	77	
Euroclean	UZ-948	270	
Euroclean	UZ-848	105	
Euroclean	UZ-878A	100	

[a] Hako is a registered trademark of Hako-Werke GMBH & Co., Federal Republic of Germany.

[b] Nilfisk is a registered trademark of A/S Fisker & Nielsen, Copenhagen, Denmark.

[c] Rad Pac and Rad Vac are registered trademarks of Power Products and Services Co., Inc.

cfm = cubic feet per minute.

Appendix B
High-Efficiency Particulate Air Filtered Vacuum Unit Associated Tools For Radioactive Contamination Removal

TOOL	APPLICATIONS	REMARKS
DESCO Mini Die Grinder with fixed shroud 2" and 3"	Removal of hazardous and nonhazardous coatings, paint scuffing, surface cleaning and preparation, weld preparation	Pneumatic only
DESCO Bullgrinder with shroud 4" and 7"	Removal of hazardous and nonhazardous coatings, paint scuffing, surface cleaning and preparation, designed to clean right to a vertical surface	Pneumatic and electric
DESCO right angle grinder with floating shroud 3", 5" and 7"	Removal of hazardous and nonhazardous coatings, paint scuffing, surface cleaning and preparation, weld preparation	Pneumatic and electric
DESCO Mini Flush Plate 2.25" Hub 3 Hubs available Cutter Hub Hammer Hub Roto-Peen Hub	Removal of hazardous and nonhazardous coatings on structural steel and concrete, grinding, abrading, surface preparation and profiling	Pneumatic and electric
DESCO FX Tool 4.25" Hub 3 Hubs available Cutter Hub Hammer Hub Roto-Peen Hub	Removal of hazardous and nonhazardous coatings on structural steel and concrete, grinding, abrading, surface preparation and profiling	Pneumatic and electric

TOOL	APPLICATIONS	REMARKS
DESCO Floor Abrador (Descobrader Walk Behind) 5.25" and 10.25" 7 Hubs available 3 Cutter Hubs Hammer Hub Roto-Peen Hub BPH Hub Clean & Strip Hub	Removal of hazardous and nonhazardous coatings, rust and non-skid, mastic removal, surface profiling, cleaning and scarifying and grinding	Pneumatic and electric
DESCO Micro Needle Descaler 2 mm needles Hand held, straight shank	Removal of hazardous and nonhazardous coatings, paint, stucco and rust, lightweight, tight-fit applications	Pneumatic only
DESCO Needle Descaler 2mm, 3mm, and 4mm needles Hand held, straight shank	Removal of hazardous and nonhazardous coatings, paint, stucco and rust, cleaning of brick and stonework	Pneumatic and electric
DESCO Surface Preparation Tool (BPH Tool)	Removal of hazardous and nonhazardous coatings, weld preparation	Pneumatic and electric
Nilfisk Drill Shield Fits 1/2" and 3/4"	Dust free drilling into hazardous and nonhazardous materials	Shroud only (drill not included)
Nilfisk Sabre Saw	Dust free cutting of hazardous and nonhazardous materials	Electric only. Saw and shroud sold as one
Nilfisk Sawzall Shroud Fits Milwaukee 6511 and 6512	Dust free cutting of hazardous and nonhazardous materials.	Shroud only
Nilfisk Oscillating Saw (Cast Cutter)	Dust free cutting of hazardous and nonhazardous materials, Asbestos pipe lagging	Pneumatic and electric
Wheelabrator Blastrac*	Removal of coatings from concrete surfaces, surface preparation, scabbling	Shot blast type

* Wheelabrator and Blastrac are registered trademarks of Wheelabrator Corporation, LaGrange, Georgia.